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NOTE

CROSS-CULTURAL DIFFERENCES IN HEMISPHERICITY: EEG ASYMMETRY DISCRIMINATES BETWEEN JAPANESE AND WESTERNERS*

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Abstract—This study was designed to test the hypothesis that Japanese subjects exhibit different patterns of resting EEG asymmetry compared with Westerners. EEG was recorded from the left and right temporal and parietal scalp regions in bilingual Japanese and Western subjects during eyes-open and eyes-closed rest periods before and after the performance of a series of cognitive tasks. Alpha activity was integrated and digitized. Japanese subjects were found to exhibit greater relative right-sided parietal activation during the eyes closed condition. This difference was found to be a function of greater left hemisphere activation among the Westerners. Various possible contributors to this cross-cultural differences are discussed.

INTRODUCTION

A NUMBER of recent reports have examined individual differences in asymmetrical hemispheric activation [2, 3, 5, 10, 16]. The available data indicates that these differences are stable [3] and that they are related to important dimensions of an individual's cognitive [5, 2] and affective [16] style.

A variety of behavioral data point toward possible differences in components of hemispheric specialization between Japanese and Westerners. The Japanese language differs from most Indo-European languages in an important respect: there are two symbol systems that comprise the Japanese language, one consisting of a relatively small number of phonemic syllables (Kana) and the other of a very large number of complex pictorial characters (Kanji). The meaning of these Kanji characters is directly associated with their visual configuration [15, 19].

The pictorial nature of Kanji characters has prompted many investigators to explore possible differences in cerebral asymmetry during the processing of Kana vs Kanji. These differences have been underscored by observations in aphasic patients who exhibited different impairment of Kana vs Kanji as a function of unilateral brain damage [13, 14]. A number of recent studies have examined behavioral asymmetries in the perception of Kana and Kanji characters. While many inconsistencies remain unresolved, the majority of the studies in this area find that singly presented Kanji characters are perceived more accurately when presented to the left visual field (LVF) compared with presentations of the identical information to the right visual field [7, 8, 18]. Multiple Kanji and single Kana characters as well as mixed Kana/Kanji groupings appear to be associated with a RVF superiority [7, 18].

This evidence reveals that Kanji characters are sometimes processed in a manner which differs considerably from that associated with most Indo-European languages. Long-term exposure to this linguistic environment of Kanji may produce detectable neuropsychological sequelae. A number of workers have speculated about this possibility [8, 9]. HATTA and DIMOND [9] have performed the first direct study of differences between Japanese and Westerners in hemispheric processing styles. Using tachistoscopic hemiretinal techniques, they found that in

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response to identical shape stimuli, Westerners showed the expected LVF superiority while the Japanese showed visual field symmetry. In response to hemifield presentation of digit sequences, a group × visual field interaction was not obtained. Both the Japanese and Westeners showed RVF superiority for this task. These data suggest that spatial cognition may be more biliaterally represented in the Japanese. At the very least their findings "strongly suggest the possibility of some cross-cultural differences with respect to cerebral dominance" [9, p. 373].

It should be noted, however, that this suggestion is not universally accepted. For example, ENDO *et al.* [4] have argued that Japanese subjects have the same basic pattern of hemispheric specialization as Westerners. They reach their conclusions on the basis of a study comparing recognition accuracy between the two visual fields for shapes vs two-syllable Kana nonsense words in Japanese subjects only. Unfortunately, ENDO *et al.* did not perform a cross-cultural comparison.

In order to further investigate differences between Japanese and Westerners in hemispheric activation, we measured bilateral EEG during both rest and task conditions. We included a baseline condition in light of previous data from our laboratory indicating behaviorally significant individual differences in measures of resting EEG asymmetry [2, 16].

METHODS

Subject selection

In selecting subjects for this experiment, it was possible to find only those Japanese individuals who also spoke English as a second language. Because of this, we wished to select a control group of Westerners who also were bilingual. In this way, we were able to rule out bilingualism as a confounding variable differentiating between the groups.

Twelve female Japanese right-handed subjects (mean age = 32.6 yr; S.D. = 9.4) with no familiar sinistrality as assessed by the Edinburgh Questionnaire [11] were recruited from the college and local communities. All but one of these subjects spoke English fluently. The Japanese subjects spoke English for a mean of 12.19 yr (S.D. = 9.87).

Twelve female Western right-handed subjects (mean age = 29.1 yr; S.D. = 13.9) with no familiar sinsistrality were recruited in the same manner and were matched as closely as possible to the Japanese on age and number of years during which a second language was spoken. Among the Westerners, 10 spoke English as a second language, while the two remaining Westerners were Americans who were fluent in another Indo-European language, (mean number of years subject spoke a second language was 18.8 (S.D. = 16.37).

Procedure

Subjects were instructed that this experiment was concerned with language and the brain. They came to the laboratory and were instructed about the nature of the tasks which were to be administered. A series of four cognitive tasks were administered to all subjects while EEG was recorded. The findings from these tasks will be reported separately. In addition to a series of cognitive tasks, baseline measures of hemispheric activation were recorded during a series of resting conditions prior to and following the cognitive task. The duration of each resting period was 18 sec. One eyes-open and one eyes-closed condition was recorded before and after the intervening tasks. Because of technical problems associated with the running of the intervening tasks, we were only able to obtain post-task baseline data on 18 subjects (9 Westerners and 9 Japanese). Order of eyes condition was counterbalanced within and randomized between subjects. During these rest periods, subjects were not given any specific instructions other than to sit quietly and relax.

Apparatus and recording procedure

Subjects were seated in a darkened subject room and all communication between subject and experimenter was via intercom. EEG was recorded with a lycra stretchable cap (Electro-cap) from T3, T4, P3 and P4 referenced to Cz. The procedure of referring to Cz has been used extensively in studies of EEG asymmetry associated with cognition and affect (see [1]). All interelectrode impedances were below 4000 Ω. EOG was recorded from the external canthus to the supra orbit to the left eye and all epochs associated with eye movement and/or muscle artifact were eliminated.

The amplified raw EEG signals were filtered for narrow band alpha (9–11 Hz) with Rockland variable band-pass filters (48 db per octave cut-offs). Filtered alpha was integrated and digitized and calibrated values in μv sec of alpha were obtained.

Results

The data were first analyzed by examining the alpha laterality ratio scores [(R – L)/(R + L) alpha]. Higher numbers on this ratio score are indicative of greater relative left-sided activation. This ratio score has been used extensively in previous research on EEG asymmetries associated with cognition and affect (see [1]).

A mixed design analysis of variance (ANOVA) with group, eyes condition (eyes open/closed), time pre-test/post-test) and region (temporal/parietal) as factors was computed on the ratio scores. The ANOVA revealed a significant main effort for region [$F(1, 22) = 13.86$; $P = 0.001$]. The means showed that across group and all other conditions, the temporal region displayed greater relative right-sided activation compared with the parietal region (mean for

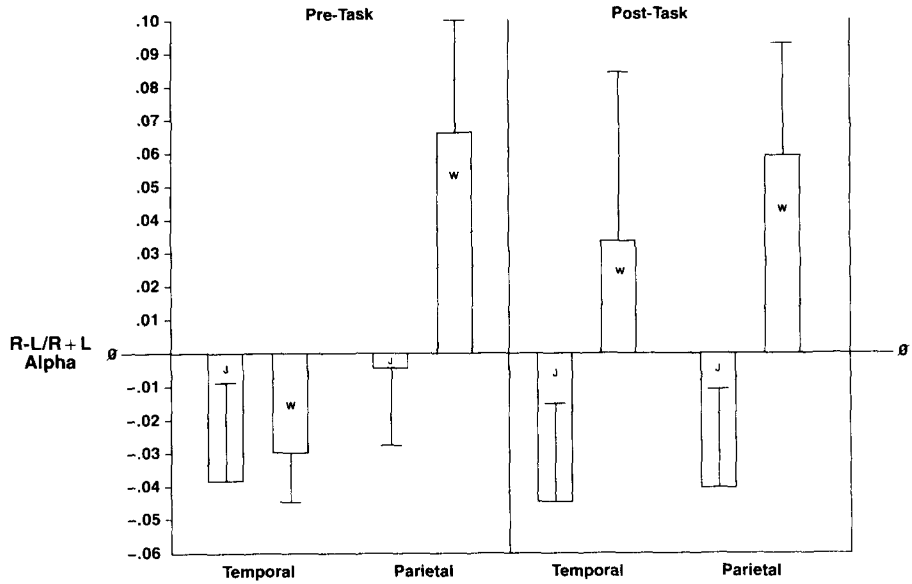

FIG. 1. Laterality ratio scores [(R − L)/(R + L) alpha] for temporal (T3 and T4) and parietal (P3 and P4) scalp regions, separately for pre- and post-test eyes closed periods for Japanese ($N = 12$ for pre; $N = 9$ for post) and Westerners ($N = 12$ for pre; $N = 9$ for post). Higher numbers of this ratio score are an indication of greater relative left-sided activation.

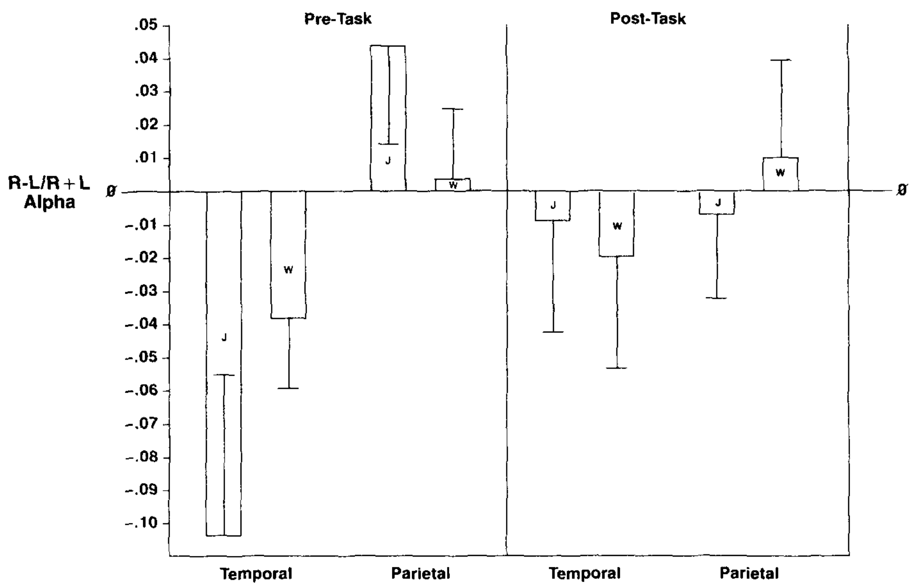

FIG. 2. Laterality ratio scores [(R − L)/(R + L) alpha] for temporal and parietal scalp regions, separately for pre- and post-test eyes open periods for Japanese and Westerners. *N*s are identical to Fig. 1.

temporal = −0.034, S.D. = 0.108; mean for parietal = 0.018, S.D. = 0.095). A significant time × region interaction was also found [F (1, 16) = 9.98; P = 0.006). Inspection of the means revealed that the difference between temporal and parietal regions was primarily in the pre-test period (see Table 1).

A marginally significant four-way interaction of group × eyes × time × region was obtained [F (1, 16) = 3.93; P = 0.065). These data was displayed in Figs. 1 and 2. As can be seen from these figures, the most robust group differences were found during the eyes closed resting condition. Separate ANOVAs on each of the individual condition region combinations indicated that only parietal asymmetry during the post-test showed significant group differences [F (1, 16) = 5.93; P = 0.03] with the Japanese displaying significantly greater relative right-sided activation compared with Westerners. The pre-test parietal eyes closed condition also shows a trend in the same direction [F (1, 22) = 2.77; P = 0.11].

Table 1. Means and S.D. of (R − L)/(R + L) alpha ratio scores for temporal and parietal leads during the pre- and post-test periods. Data are across group. Higher numbers on the ratio score are indicative of greater relative left-sided activation.

	Pre-task		Post-task	
	Temporal	Parietal	Temporal	Parietal
Mean	−0.052	0.026	−0.009	0.007
S.D.	0.106	0.098	0.107	0.090

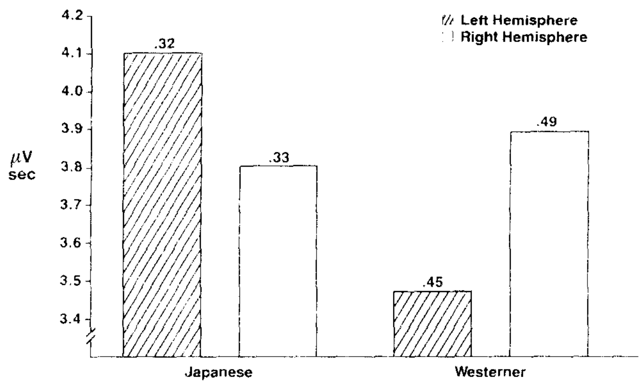

FIG. 3. Alpha activity (in μV sec) for left and right parietal leads, separately for Japanese and Westerners for the post-test eyes-closed period. Numbers above each bar are the standard error of the mean.

An ANOVA with hemisphere and group as factors was computed to ascertain which hemisphere contributed most to the significant group differences in parietal asymmetry which was uncovered in the ratio score analysis. The ANOVA for the eyes closed post-test parietal data revealed a significant group × hemisphere interaction [F (1, 16) = 5.33; P = 0.035] (see Fig. 3). These data indicate that the group difference is primarily a function of Japanese subjects displaying more alpha (i.e. less activation) in the left hemisphere compared with Westerners. No difference between groups was obtained in right-hemishphere alpha.

DISCUSSION

These data suggest that Japanese and Western subjects differ in patterns of baseline asymmetric activation. Specifically, we found group differences only on the eyes-closed condition where Japanese subjects displayed greater relative right-sided parietal activation compared with Westerners. The group difference was independently significant only for the post-test period. The difference was accounted for by group differences in left-hemisphere alpha only with the Westerners showing more activation (i.e. less alpha) than the Japanese.

These data suggest the Japanese subjects may differ from Westerners in the degree to which different hemispheric processing strategies are characteristically activated. While the data do not directly support HATTA and DIMOND's [9] assertion that the right hemisphere contributes more to the processing of verbal material in the Japanese than in the Westerner, they do raise the possibility of differences between groups in patterns of tonic hemisphere activation.

We consider it significant that Japanese subjects did not show this pattern during all baseline periods. The precise explanation for this is currently not known and will require further study. However, the fact that Japanese subjects did not consistently show this pattern indicates that our finding is not an artifact of our recording procedure, electrode placement or systematic cultural differences in skull thickness asymmetry.

A number of investigators have suggested that individuals may differ in their characteristic hemispheric processing styles. In previous research from our laboratory [2], we have demonstrated that individual differences in baseline asymmetric activation predict subsequent cognitive performance. Whether such cognitive style differences also distinguish between Japanese and Western subjects is not currently known although it would be predicted on the basis of our findings.

In conclusion, these data, in conjunction with other behavioral and neuropsychological findings [6, 12, 17] suggest that fundamental biocognitive differences may exist between different cultural groups. The origins of these characteristic processing styles are not known, but our data indicate that this area warrants further study.

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